An Approach to Embedded Training for Future Leaders and Staff

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ABSTRACT

Unlike many other U.S. Army procurement programs, the Future Combat Systems (FCS) program placed a premium on the design of training platforms and training content. All developers of FCS technologies were required to develop training concurrently. Thus, developers of the Unattended Ground Sensors (UGS), now being tested, delivered new equipment training with the UGS themselves. In addition, the FCS program required the widespread use of embedded training (ET) across platforms. This paper discusses both the tremendous opportunities and serious challenges of ubiquitous embedded training as proposed in the FCS program. While such widespread ET seems to offer near "any time any place" training, it also places heavy costs on the unit. In addition, widespread ET could cause the misapplication of ET technologies to training that could best be addressed using other approaches. That is, ET could drive the content of training and the design of training strategies, rather than the content and strategy driving the selection of appropriate training approaches and platforms. Thus, a major challenge is how to fit ET into a training strategy in an effective and efficient manner. To illustrate these issues, the training of leaders and battle staff will be used as a case study.

1.0 INTRODUCTION

To be successful in this networked environment, future leaders and staff must understand how to: a) employ the assets of a future unit to their fullest capabilities in an integrated manner; b) organize, comprehend, and utilize the vast amount of information available via the network, c) collaborate across operational roles, echelons, and unit types, in a distributed, fluid, networked environment; and, plan continuously in order to adapt capabilities to the perceived or predicted enemy situation.

Effective training of its leaders and staff will be key to the success of the Future Force. In the future, training must be available anywhere, anytime to meet a wide range of dynamic requirements. To provide this availability, the primary method of training the Future Force will be through the embedding of training, and supporting information, materials, and tools in operational networks and platforms. Training will thus be accessible through any computers serving as a portal to operational networks; this will include computers that Soldiers use on operational systems or platforms, as well as desktop or portable computers. The capability to provide embedded training at individual- and collective levels in live, virtual, and constructive training environments will be an essential part.

The Army's Future Force Integration Directorate (FFID) has identified that the requirements of network-enabled battle command requires novel training approaches that will train leaders and staff how to think in this environment. This reflects a change from how most battle command training occurs. Traditionally, battle command training tends to be of three types: task-based, button-based, or process-based. Task-based

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14. ABSTRACT
Unlike many other U.S. Army procurement programs, the Future Combat Systems (FCS) program placed a premium on the design of training platforms and training content. All developers of FCS technologies were required to develop training concurrently. Thus, developers of the Unattended Ground Sensors (UGS), now being tested, delivered new equipment training with the UGS themselves. In addition, the FCS program required the widespread use of embedded training (ET) across platforms. This paper discusses both the tremendous opportunities and serious challenges of ubiquitous embedded training as proposed in the FCS program. While such widespread ET seems to offer near any time any place training, it also places heavy costs on the unit. In addition, widespread ET could cause the misapplication of ET technologies to training that could best be addressed using other approaches. That is, ET could drive the content of training and the design of training strategies, rather than the content and strategy driving the selection of appropriate training approaches and platforms. Thus, a major challenge is how to fit ET into a training strategy in an effective and efficient manner. To illustrate these issues, the training of leaders and battle staff will be used as a case study.

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training focuses on the performance steps in the completion of an individual, Leader-Battle Staff, or collective task. Button-based training focuses on how to operate the battle command systems (e.g., what sequence of buttons to press to send a situation report). Process-based training focuses on the procedures followed by staff as they work together within a command post or operations center. While each of these kinds of training will be necessary to train future leaders and staff, FFID has identified the need for cognitive-based training.

The US Army Research Institute for the Behavioral and Social Sciences (ARI) unit at Fort Knox, KY has been conducting research on methods of cognition-based training. The methods are designed to effectively and efficiently train the expert cognitive behaviors needed during the execution of rapidly changing military operations. In particular, ARI has developed the Adaptive Thinking Training Methodology and the corresponding Think Like a Commander (TLAC) and Red Cape training programs.

The Adaptive Thinking Training Methodology and TLAC apply deliberate practice concepts to train tactical battle command skills that enable students to model their thinking, understanding, plans, visualizations, and decisions after expert thinking patterns. A critical component in the construction of the TLAC training is the explicit development of a set of expert tactical considerations. In TLAC training, the expert patterns are: (1) keep a focus on the mission and higher intent, (2) model a thinking enemy, (3) consider effects of terrain, (4) use all assets available, (5) consider timing, (6) see the big picture, (7) visualize the battlefield, and (8) consider contingencies and remain flexible. These eight cognitive behaviors are called the Themes of Battlefield Thinking and represent the elements of expert form that the coaches exhibit and the students learn to model.

There are four distinct phases to the deliberate practice training approach. First, students are presented with a short multimedia situation. Following the presentation, students are required to perform the appropriate tasks. In the case of the TLAC training for battlefield thinking skills, the task is to identify considerations that are key and critical aspects of the situation. Next, students are provided with a discussion of expert considerations pertaining to each of the battlefield thinking skills. In the original TLAC, this discussion is led by an instructor. A DVD and web-based version of TLAC (Captains in Command) presents a simulated discussion led by a 3-D animated coach. Finally, the students are required to compare and score their considerations based on the expert considerations. The deliberate practice method has been used to train tactical skills in brigade, battalion, and company commanders and assists in converting knowledge into actual cognitive behaviors that can be observed, measured, and coached.

The purpose of this paper is to present the cognitive requirements identified as unique to FCS operations and describe their use as the basis of exemplar training vignettes targeting FCS cognitive skills. We begin with a brief description of the CTA conducted to identify the eight themes, describe the content validation study and its resultant set of eight FCS cognitive themes, describe our methodology for developing the training vignettes, and conclude with a discussion of the study's limitations and requirements for future research.

2.0 INITIAL COGNITIVE TASK ANALYSIS

We specified three research objectives to guide our exploration of the FCS cognitive domain. First, we sought to identify the cognitive requirements in the FCS envisioned world. Second, we questioned whether the cognitive processes and skills required of FCS operations were qualitatively different from those of the current force. Finally, we investigated the cognitive challenges of FCS operations most likely to be accountable for mission failures. We then applied CTA methods to address these questions.

2.1 Data Collection

The data collection consisted of individual interviews and focus groups. We generated protocols for each type of data collection session, implementing aspects of the Critical Decision Method (Hoffman, Crandall, & Shadbolt, 1998) and Knowledge Audit (Militello & Hutton, 1998) knowledge elicitation techniques.

The FCS operating environment is an envisioned world (e.g., Decker & Woods, 1999). Therefore, the CTA could not rely on Soldiers and leaders with extensive FCS operational experience as interviewees. Instead, we relied on a range of experience sets to glean the required data. Realizing we would not find "experts" in FCS operations, we targeted the following types of people as the best Subject Matter Experts (SME) available to us:

- Individuals possessing personal experience with simulated FCS or other Future Force operations
- Individuals who have observed simulated FCS operations, trained personnel to operate in the FCS environment, or analyzed FCS environments from an operator's perspective
- Individuals with extensive personal experience operating current forces, and enough knowledge of the FCS platforms and technologies to contrast the two environments

2.2 Data Analysis

We conducted a three-phase iterative process of qualitative data analysis. In the first phase, *Data Reduction*, we transformed interview and focus group notes and transcripts into items for analysis. In the second phase, *Construct Identification*, we iteratively identified and sorted data items into FCS cognitive themes. In the third phase, *Elaboration and Refinement*, we defined each theme, identified how the FCS cognitive requirements were unique compared to current force cognitive requirements, and specified cognitive challenges associated with performance of the theme. For a full description of the analysis process, see Phillips, Ross, Crabb, & Grover (2009). We concluded by producing eight FCS themes representing the primary cognitive requirements of FCS, which were distinct from current force operations. Within each theme, we specified the elements of the cognitive task that were unique to the FCS environment and thereby generated a list of *Unique FCS Features*. We confirmed with our military SME that the features identified were indeed unique to FCS. We also specified cognitive challenges related by interviewees. We again confirmed with our military SMEs that the challenges we had identified from the data were 1) accurate depictions of FCS task requirements and 2) sufficiently novel in the FCS environment to warrant inclusion as a cognitive challenge, which would later translate into an implication for training. We then generated a list of *Cognitive Challenges* for each theme.

2.3 Initial FCS Cognitive Themes

Based on our data analysis, we present the following eight initial FCS cognitive themes:

- Employ FCS Capabilities
- Develop Intelligence
- Visualize and Describe the Area of Operations

- Perform Predictive Analysis
- Share Situational Understanding
- Demonstrate Individual Initiative
- Sustain Unit Operations
- Plan Continuously

3.0 CONTENT VALIDATION OF THE FCS COGNITIVE THEMES

The purpose of the content validation stage was to conduct an objective analysis of the eight FCS cognitive themes to determine whether they adequately and accurately captured the cognitive requirements of FCS operations. Specifically, we sought to validate the operational definitions, Unique FCS Features, and Cognitive Challenges. Data were collected in the context of the Initial Mission Training (IMT-1) Tactical Leader Course at Fort Bliss, TX.

3.1 Methodology

We designed a content validation approach using quantitative and qualitative data collected from Soldiers to assess the relevance of the eight cognitive themes for FCS operations. The methods employed included focus groups, interviews, and surveys to obtain data required to confirm the themes and their components as descriptive of the critical cognitive requirements associated with FCS operations.

3.2 Sample

We implemented our data collection plan in the context of the 10-day IMT-1 activity in which the battle staff from the 1st Combined Arms Battalion (CAB), Army Experimentation Task Force (AETF) performed battle command functions from instrumented mocked-up combat vehicles. Of the 1st CAB's 130 personnel, 52 participated in IMT-1, and we obtained 20 Battle Staff and Command Soldiers and leaders for our sample. The criteria included participation in other experiments and adequate length of service with the AETF, having had assignments with digitized Army units, and having had assignments with Stryker BCTs.

3.3 Focus Groups

We planned focus groups as the primary means of collection of qualitative validation data. We prepared eight focus group protocols, each addressing a single cognitive theme. Each protocol consisted of a purpose statement, a definition of the theme under examination, a priming question, and a series of specific probes that followed. We identified the desired participant qualifications by duty position for each focus group, and the unit selected the specific individuals who would participate. Each group consisted of three or four Soldiers. No Soldier participated in more than two focus groups, and we facilitated each group discussion and digitally recorded every focus group.

3.4 Interviews

We prepared an interview protocol for FCS SMEs to allow for feedback on each theme. The protocol was based on Competency Analysis and Knowledge Audit (Militello & Hutton, 1998) techniques, and consisted of a purpose statement, a priming question, and a series of probes to elicit information about cognitive abilities and training requirements for FCS operations. We conducted two 1-hour SME interviews.

3.5 Survey

We administered a five-part survey to collect quantitative data to determine the content coverage and applicability of the proposed eight cognitive themes. In Part 1, we collected demographic information. In the second section, respondents rated the difference between a sample of 45 Unique FCS Features and the Current Force Capabilities on a scale from one to five with one being "Not at all different from current force operations" and five being "Completely different requirements for my duty position in the CAB." Each Soldier was asked to cluster the 45 Features under one or more themes or none at all. In Part 3 of the survey, Soldiers were asked to rate the criticality of each of the 58 Cognitive Challenges to mission success on a five-point scale with one meaning "Not at all important" and five representing "Extremely important." The final section entailed the Soldiers clustering the 58 Cognitive Challenges under one or more themes or none at all.

3.6 Data Analysis

We independently assessed the eight cognitive themes to determine content validity. This resulted in the restatement of the theme definition from the Soldiers' perspective, the verification of the Unique FCS Features that distinguish the FCS environment from legacy systems, and the validation and rank ordering of the Cognitive Challenges. We conducted qualitative and quantitative analyses to examine the data set. Because of the small number of survey responses, we heavily weighted the qualitative focus group and interview data when validating the theme definitions, Unique FCS Features, and the Cognitive Challenges.

3.7 Qualitative Analysis

We hypothesized that the initial CTA produced accurate themes, definitions of the themes, Unique FCS Features, and Cognitive Challenges, which Soldiers would accept as important to unit performance. These estimates were the focus to our validation process. For qualitative data like the focus group discussions, we established validity in three stages.

- Concept Saturation. As we introduced a number of topics, trends began to emerge. When Soldiers reported the same type of finding or conclusion during the session and there was generalized, within-group agreement, we judged that we had achieved concept saturation. We achieved a complete data set when SME interviews and focus groups began to reveal the same findings as previously reported.
- Traceability. Over time, we reduced and represented the narratives in analysis worksheets and maintained a record of the specific source for each entry to prevent data contamination.
- Review. An experienced, knowledgeable individual reviewed the analysis worksheets to confirm relevant and attributable trends.

We used evidence of concept saturation, repeated instances of the same issue or concept across several interviewees or focus group participants, as our primary test for validity. Each focus group participant and interviewee confirmed that the eight themes, judged by their titles and definitions, represented key cognitive requirements in the FCS operational environment. Soldiers judged each theme as distinct from the others and assessed that the eight themes captured the critical components of FCS cognitive

performance. Therefore, the qualitative analysis process focused on revising the theme definitions and descriptions of Unique FCS Features and Cognitive Challenges within each theme as opposed to the themes themselves.

We utilized analysis worksheet outputs from the focus groups to initiate the qualitative analysis. These worksheets specified each group's agreement on revisions to the three aspects comprising each theme, including additions, deletions, and changes to existing descriptions. We found that in most cases, focus group participants and interviewees agreed on the revised theme descriptions. Because of the high experience levels of the interviewees in our sample, we justified their additional insights for inclusion to the themes.

3.8 Quantitative Analysis

We used quantitative measures of content validity to validate the Unique FCS Features and Cognitive Challenges. Analysts applied the Cohen's Kappa method to measure inter-rater reliability (Cohen, 1960) and Lawshe's Content Validity Ratio (CVR) (Lawshe, 1975) to measure content validity of the survey data.

3.9 Ranking of Cognitive Challenges

After revising the eight cognitive themes in accordance with the findings, analysts and a SME independently ranked ordered the Cognitive Challenges by theme by a priori stating the ordering criterion as: The extent to which the absence of the cognitive ability would result in a mission failure. Thus, Cognitive Challenges ranked highly were more likely than lower ranked items to result in mission failure if Soldiers were unable to perform the challenge adequately. The rankings guided the training development portion of the effort. Cognitive Challenges of high relative importance must be the primary objectives for training interventions.

4.0 RESULTS

The qualitative analysis resulted in additions, revisions, and deletions to the original theme descriptions. Focus group participants and interviewees were in agreement that the themes adequately captured the full range of cognitive requirements they have encountered and envisioned within the FCS operational environment. We, therefore, considered the eight themes as valid general descriptions of FCS cognitive requirements.

Of the 20 Soldiers providing survey data, we compared 190 pairs of responses to assess reliability. For the Unique FCS Features items, we eliminated one respondent's data because of incomplete responses. For the Cognitive Challenges data, we eliminated two Soldier surveys because of incomplete data. This provided 19 Soldiers for the Unique FCS Features questions, and 18 for the Cognitive Challenges items, creating 171 and 153 pair wise comparisons, respectively.

We investigated the Likert scale data for content validity using the CVR. The CVR is a value between -1 and 1, representing the validity of the specific challenge. Of the 20 Soldier respondents, 2 of them gave no answers at all on these sections, and 1 provided only a few. We eliminated other Soldiers from the sample

because of their lack of experience as reported in Part 1 of the survey. Thus, we only identified 11 Soldiers whose responses could be used in the analysis. This small sample size makes this measure less than compelling, but instructive nonetheless.

4.1 Cohen's Kappa Analysis

Of the 171 pairs using the Unique FCS Features questions at the 0.05 level of significance, only 26 pairs revealed a significant correlation or close agreement among pairs of Soldiers. This is only slightly greater than the roughly eight or nine false positives that one would expect at this level of significance. Together, this suggests very low agreement among Soldiers and fails to quantitatively validate the results of the original CTA. Combined with the very low sample size, this does not validate content validity.

Of the 153 pairs evaluated using the Cognitive Challenges questions at the 0.05 level of significance, only 20 pairs revealed a significant correlation. This is only slightly greater than the roughly seven or eight false positives that one would expect at this level of significance. Again, this suggests very low agreement among Soldiers and fails to quantitatively validate the results of the original CTA.

4.2 Lawshe's CVR Analysis

For Unique FCS Features, we took responses of 3, 4, or 5 to indicate a meaningful difference from current force requirements. Note that these ratings are skewed because of sample size. While a positive CVR indicates some degree of uniqueness, we used a value of 0.63 to suggest significant differences. Table 1 shows the range of CVR values achieved for the Unique FCS Features.

Table 1. CVR Values for Unique FCS Features

CVR	#
< 0	3
0 to 0.19	2
0.20 to 0.40	4
0.40 to 0.59	3
0.60 to 0.79	9
0.80 to 0.99	5
1.00	19
Total	45

Using the same 11 Soldiers from the Unique FCS Features CVR ratings, we analyzed the Cognitive Challenges Likert data. Each of the Soldiers rated each Cognitive Challenge on a five-point scale to determine its importance to mission accomplishment. We used these ratings to calculate the CVR for each Challenge.

All Challenges, except one, received a positive CVR when measuring whether they were deemed important to mission success. Table 2 reports the results, taking any result of "important," "very important," or "extremely important" as an indication that the Cognitive Challenge is necessary.

Table 2. CVR Values for 58 Cognitive Challenges

CVR	#
< 0	1
0 to .19	0
.20 to .40	1
.40 to .59	0
.60 to .79	8
.80 to .99	26
1	22
Total	58

As the table shows, 48 out of 58 Cognitive Challenges had a CVR of 0.80 or higher, and all except one had a value of 33% or higher. Because of the small sample size, a CVR of 0.62 or above is required to ensure that these results were not achieved by chance alone. Therefore, this investigation suggests content validity for 55 of the 58 Cognitive Challenges.

As a general rule, we considered Unique FCS Features with CVRs greater than 0.62 and Cognitive Challenges with CVRs greater than 0.64 valid and retained them as items in their corresponding themes. However, given the small sample of survey respondents and their lower levels of experience compared to focus group participants and interviewees, analysts weighted the outcomes of the qualitative analysis more heavily than the quantitative findings. Thus, in some cases, we deleted items with acceptable CVRs and retained others with relatively low CVRs when strongly recommended by the Soldiers we spoke with in person.

We cannot answer all questions about the extent of agreement among Soldiers with regard to assigning the Unique FCS Features or Cognitive Challenges to individual cognitive themes because of the low reliability of the data. Since the Soldiers clearly had at least two different approaches to the survey (some gave multiple answers; some did not), we cannot directly compare their responses.

4.3 Ranking of Cognitive Challenges

The ranking process produced two sets of ordinal lists for each theme: an analyst list and a SME list. We then assessed the lists to determine a level of agreement using Spearman's Rank Order Correlation, *rho* (Spearman, 1904). Each ordinal ranking by theme correlated to estimate the level of inter-rater reliability and the significance of the correlation as shown in Table 3.

Table 3. Inter-rater Reliability for Each Theme

Theme	Spearman's *rho*	*p*-value
Theme 1	0.72	0.04
Theme 2	0.65	0.02
Theme 3	0.80	0.16
Theme 4	0.61	0.14
Theme 5	0.69	0.07
Theme 6	0.90	0.01
Theme 7	0.80	0.02
Theme 8	1.00	0.01

Taken together, the qualitative and quantitative analyses suggested the need for several revisions to the component parts of the themes, and those revisions were made. Here, we report the final set of themes with their validated definitions and Cognitive Challenges. We ordered the Cognitive Challenges by priority according to the SME's rankings. We did not consider the Unique FCS Features to be sufficiently validated by the analysis; therefore, we do not report them here. However, for a list of the features, the reader can reference Phillips et al. (2009).

4.4 Theme 1: Employ FCS Capabilities

Theme 1 is defined as the ability of individuals and collective organizations to understand and apply the capabilities and limitations of a new system-of-systems, which is connected through the network. The systems include Soldiers, manned and unmanned weapons and sensors, networked communication and collaboration, and customizable interfaces. The top four of the eight Cognitive Challenges associated with Theme 1 are the following, in order of importance:

- More capabilities exist at lower echelons. Requirements to coordinate, monitor, adjust, and communicate produce high cognitive workload.
- Soldiers must assess performance against mission goals across the network over time. Leaders must integrate Soldiers and robotic assets to perform cooperative ISR and fire missions.
- Soldiers must optimize use of Non-Line of Sight (NLOS), Beyond Line-Of-Sight (BLOS), and sensor platform standoff capabilities to shape the battlefield.
- Soldiers must develop understanding (mental models) of affordances and limitations of new weapons platforms.

4.5 Theme 2: Develop Intelligence

Theme 2 is defined as the ability of individuals and collective organizations to visualize operations, identify Commander's Critical Information Requirements (CCIR), focus and prioritize reconnaissance and surveillance assets, turn information gained from an integrated network of human and robotic sensors capable of seeing and analyzing the entire operational environment into intelligence, redirect sensors based on new information and recommend courses of action (COA) as part of the Collaborative Multi-Echelon Planning (CMEP) process.

TRADOC Pam 525-66 Force Operating Capabilities describes CMEP as a way to expedite the classic Military Decision Making Process (MDMP) by utilizing advanced technological tools. These tools have the ability to operate in dynamic and uncertain information environments. Given this ability, they allow for better and timelier decisions. The top 4 of the final 13 Cognitive Challenges associated with Theme 2 are:

- Since the quantity of information is so great, Soldiers must understand what they need to know, identify what they don't know, and be disciplined in the collection process.
- The Unit must establish effective collaborative teams to analyze, interpret, or fuse information into usable/actionable intelligence.
- Soldiers must develop new strategies to gather information needed to accomplish mission goals such as taking an action to obtain information when required feedback is not received from a typical source.
- Soldiers must de-conflict or assign significance to information sources or collection platforms.

4.6 Theme 3: Make Sense of Information

Theme 3 is defined as the ability of individuals to make sense of the multiple, simultaneous data elements from a range of digital, electronic, and other sources and generate a visualization of the operational environment in support of the mission as well as the ability to express that visualization in a way that can be disseminated to higher and/or subordinate units using the FCS suite of tools. The four Cognitive Challenges associated with Theme 3 are:

- Soldiers must use a new digital cue set via the Warrior Machine Interface (WMI) to develop situational awareness (SA) and turn it into situational understanding (SU). They must transform digital cues into a mental picture of the operational environment.
- Soldiers must assess the reliability of hard-to-believe information.
- Soldiers lose important cue sets—hearing, seeing, smelling, feeling the area of operations (AO)—for developing SA.
- Soldiers must judge and test the credibility of information, acknowledging that first reports will still be inaccurate and that multiple ambiguous reports may still require de-conflicting.

4.7 Theme 4: Perform Predictive Analysis

Theme 4 is defined as the ability of trained and experienced Soldiers to apply the information obtained through the FCS network about the situation to anticipate the actions needed to plan and act more quickly than the adversary, i.e., the threat and affected population. Soldiers use what they know about current and past adversary behaviors, consider the factors of Mission, Enemy, Terrain, Troops, Time, and Civilian Considerations (METT-TC), and develop perceptions about the situation and their understanding of the adversary's goals to project how the adversary will likely change. They use their knowledge about the adversary to shape the enemy's decision cycle and behaviors. The top four of seven Cognitive Challenges related to Theme 4 are:

- Rapid predictive analysis requires each Soldier to know where he/she fits in the big picture and is enhanced when the Soldier understands why his/her analysis is important.
- Collaborative Intelligence Preparation of the Battlefield (IPB) must be conducted between echelons.
- Networked sensor systems may give a false sense of near complete knowledge of the enemy if there is no follow-up to verify accuracy, completeness, or consistency.
- Soldiers must take the perspective of an overmatched, asymmetric adversary.

4.8 Theme 5: Share Situational Understanding

Theme 5 is defined as the ability of individuals to communicate what they understand about the situation across the collective organization in a manner that is continuously accessible and understood by others. Shared understanding enables Soldiers and leaders to make better decisions and plans, anticipate decision points, apply individual initiative based on their shared understanding, and recognize when differences in understanding result in inconsistencies that must be corrected. We validated eight Cognitive Challenges for Theme 5. The top four are:

- Soldiers must verify information and its interpretation as the situation evolves, using the full range of FCS network tools.
- Soldiers must express the rationale for their SU to others when there are differing interpretations of information. This can be difficult when it is experienced as a gut feeling.
- Soldiers must break tendency to assume that shared SA equals shared situational understanding.
- Soldiers must know information requirements of others by role and mission.

4.9 Theme 6: Demonstrate Individual Initiative

The definition for Theme 6 is the ability of Soldiers and Leaders to operate rapidly, confidently, and independently as the situation evolves, making use of intuition, judgment, and understanding of the Commander's intent and guidance. Individual initiative enables effective, decentralized execution and requires shared situational understanding of METT-TC and proficiency with the roles and responsibilities of each FCS node in order to accomplish mission goals. We validated 12 Cognitive Challenges for Theme 6. The top four are:

- Soldiers must understand how to work with new information management tools.
- Soldiers must understand what other units are doing in order to take appropriate initiative.
- Soldiers must develop measures of effectiveness tied to mission end state, objectives, or effects so that the Soldiers and Commanders know when to change mission focus with minimal pause.
- Soldiers must assess 2nd and 3rd order effects in order to better capitalize on follow-on operations.

4.10 Theme 7: Sustain Unit Operations

Theme 7 is defined as the ability of Soldiers and Leaders to generate a sustainment concept and plan to rearm, refuel, refit, and reconstitute manned, unmanned, mounted, and dismounted systems without disrupting the pace of operations. Use total asset visibility through the WMI to support current and planned operations and efficiently adapt to logistics requirements before they impact friendly operations. Provide for the needs of Soldiers in order to sustain their vigilance and readiness. Identify capabilities and constraints due to sustainment requirements. The top four of the nine Cognitive Challenges associated with Theme 7 are:

- Soldiers must track logistics consumption rates and personnel loss information to support in-stride planning for sustainment of future operations.
- Soldiers must synchronize pulse logistics requirements based on the current and anticipated missions, taking into account time required to order and transport supplies.
- Soldiers must understand how current and projected logistics status will affect tactical operations.
- Soldiers must anticipate where and when sustainment pauses might be necessary.

4.11 Theme 8: Plan Continuously

Theme 8 is defined as the ability of individuals and collective organizations to use SU to continuously, collaboratively, and simultaneously plan for and execute the commander's vision of end states while conducting current operations. Continuous planning encompasses in-stride planning and planning for next missions. The planning activities depend on the integration and synchronization of the current situation template (SITTEMP) with the projected future enemy SITTEMP as it relates to the terrain, friendly forces, and non-combatants. Individuals must also assess progress toward current mission objectives to maintain or modify actions or priorities. The top four of the eight Cognitive Challenges associated with Theme 8 are:

- Soldiers must continuously translate understanding and intent, at multiple echelons, of current operations into implications for future plans.
- Soldiers must know when they have enough information to plan for, prepare for, and execute a mission; they must not search for the 100% solution.
- Soldiers must understand that collaboration does not equal synchronization.
- Soldiers must accurately communicate analysis and COA input from geographically dispersed locations.

5.0 FCS COGNITIVE SKILLS TRAINING

To implement our goal of reinforcing the cognitive themes in FCS Soldier performance, we developed a series of five multimedia vignettes with the intent to provide training and exemplars to the FFID for what cognitive skills training could look like. Our intent was to provide a platform for the FFID and AETF to develop additional training vignettes to be embedded in line with FCS training concept and requirements. We developed a series of four training FCS scenario vignettes to integrate individual and collective FCS tasks that included: 1) the battalion commander, 2) the battalion staff, 3) the company commander, and 4) a platoon leader. In addition, an introductory vignette provided a robust overview of the FCS and the integration and interoperability across all levels of battalion, company, and platoon operating spectrums.

5.1 Method

The scope of a single vignette was not sufficiently broad enough to incorporate all eight themes. Therefore, we addressed a subset of the themes in each vignette, ensuring that we addressed all themes at least once across the four training vignettes, not including the introduction vignette. We then identified which themes would be addressed within each vignette with some iteration to determine which themes would fit together in a story line. Following this, we correlated these themes to determine causal links across the themes and ranked the cognitive challenges to determine the priority of delivery within the vignettes. We then initiated vignette development using storyboarding, which we used to choreograph the vignette scenarios.

The storyboarding process began with SMEs developing a tactical scenario and integrating the FCS net-centric functions within the vignettes to provide a visual representation of the integrated WMI functions across the battalion, company, and platoon levels. Once we developed the initial concept and FCS

integration functions, the FFID and AETF SMEs validated our concepts, which we then finalized production development at the user level. At this point, our multimedia developers finalized these vignettes and provided us with the opportunity to review and update following SME review. The learning tool we used to evaluate learning objectives was Checks on Learning (COL). These COL were a mix of text response, "Drag and Drop," traditional 3D animation, and MetaVR Virtual Reality Scene Generator (VRSG) animations. The text responses allowed for the learner to write a response to the COL; the Drag and Drop allowed the learner to drag FCS on an electronic sand table based on tactical requirements within the vignette to allow for a cognitive-based learning evaluation tool.

5.2 Results

5.2.1 Introduction Vignette

This vignette introduces a series of tactical vignettes to assess the vignette characters' actions based upon the cognitive themes developed during this research. Within this vignette, we developed a sample scenario to introduce the learner to the other four scenarios. This vignette demonstrated how CAB staffs and leaders would use the cognitive themes and FCS capabilities to conduct the CMEP process at the CAB, company, and platoon level. The embedded vignette shows a CAB staff using FCS tools, systems, and capabilities to conduct battle planning on the move as they respond to a rapidly changing operational and tactical situation.

In addition, this vignette (and each of the training vignettes) highlighted the use of the CMEP process in staff and unit leader roles in tactical situations identifying specific FCS cognitive capabilities, which will require CMEP in lieu of the former Military Decision Making Process (MDMP). The Future BCT (FBCT) focused on seizing, retaining, and exploiting the initiative while executing operations and emphasized how the commander uses maneuver as the primary method to achieve this objective.

For the FBCT to maneuver effectively, the critical learning points delivered were that it must compete for knowledge and achieve information superiority, retain operational freedom of action through maneuver, and sustain combat power. In addition, this vignette demonstrated that units maintain their freedom of action throughout maneuver by conducting precise movements on multiple axes, avoiding terrain and obstacles that degrade their mobility. The five key tenets of tactical maneuver of the FBCT include:

- simultaneous and continuous operations that imposes unrelenting pressure on the adversary,
- conduct decisive maneuver, maintaining access to joint capabilities at the lowest tactical level, which facilitates the FBCT effort's to complete operations decisively while sustaining resources to move from one objective to the next without pause,
- integrating self-synchronization and cooperative engagements with the brigade's precision maneuver to generate effects that the FBCT uses to exploit and destroy the threat,
- and execute tactical maneuver based on the concept of "See First, Understand First, Act First, and Finish Decisively" using superior situational understanding, knowledgeable leaders and Soldiers, and other supporting capabilities.

5.2.2 Vignette 1

This vignette was entitled, "Introduction to Cognitive Leader and Battle Staff Training, Vignette 1, FCS Battalion Commander Cognitive Behaviors in Planning a Deliberate Attack." The cognitive themes, Share Situational Understanding, Make Sense of Information, and Plan Continuously, were addressed in this vignette.

This vignette utilized a 3D avatar to create a personal, adaptable, and engaging delivery approach. The 3D avatar acted as both a mentor and instructional agent. The avatar was the 1st Combined Arms Battalion Commander, LTC Rogers, and he introduced staff planning in a deliberate attack using the WMI. The scenario began with the 1st CAB located in a tactical assembly area (not in contact with enemy forces), conducting continuous planning processes where the FBCT Operations Order, to include a Brigade ISR Annex, ISR Matrix, and operations graphics, had just been issued. LTC Rogers determined that a collaborative session using the WMI Collaborator was required with his staff and commanders to describe his mental image or visualization of the upcoming mission, to synchronize his staff, and to build situational understanding. The collaborative planning process determined LTC Rogers' desired end state. Four learning points are addressed:

- Introduce the WMI.
- Understand how company commanders participate in collaborative sessions.
- Review the issuance of battalion level orders process.
- Integrate the battalion staff, to include the operations, ISR, and Engineer officers and staff positions.

5.2.3 Vignette 2

The second vignette was entitled "Introduction to Cognitive Leader and Battle Staff Training, Vignette 2, FCS Staff Cognitive Behaviors in Responding to a Fragmentary Order." It addresses four of the cognitive themes: Share Situational Understanding, Perform Predictive Analysis, Sustain Unit Operations, and Employ FCS Capabilities. This vignette, designed for battalion staff members, utilized a 3D avatar as both a mentor and an instructional agent. The 3D avatar was portrayed as a Commander, 2nd CAB of the 5th FBCT. The instructional agent/3D avatar demonstrated how he uses his staff to respond to changing situations. The four learning points in this vignette pertain to how the 2nd CAB commander's ISR Officer:

- Reacted to the receipt of a fragmentary order (FRAGO)
- Collected information to develop situational awareness to share to assist in developing his situational understanding
- Employed the unique capabilities of the FBCT to conduct predictive analysis and develop orders
- Worked with the CMEP to respond to the receipt of a FRAGO

5.2.4 Vignette 3

The third vignette was entitled, "Introduction to Cognitive Leader and Battle Staff Training. FCS Company Commander Cognitive Behaviors in Conducting an Attack." In this company-echelon vignette, Share Situational Understanding, Develop Intelligence, and Employ FCS Capabilities were developed. This vignette brought to life a 3D avatar named CPT Stewart, the Commander of Charlie Company, 2nd CAB. This vignette demonstrated how he moves his company from a Sustainment Replenishment Operations (SRO) site to execute a company-sized attack to destroy a defending enemy dismounted infantry platoon. The SRO provides an accelerated exchange of supplies consisting of rearm, refuel, fix, and medical support. The three learning points in this vignette are:

- Understand how the company developed situational awareness and how the commander shared his vision and Situational Understanding.
- Observe techniques of how the commander and subordinate units developed intelligence and used predictive analysis.
- Observe how the company employed unique FCS capabilities to conduct the attack.

5.2.5 Vignette 4

The final vignette was entitled "Introduction to Cognitive Leader and Battle Staff Training. FCS Platoon Leader Cognitive Behaviors in Conducting an Attack." In this platoon-level vignette, five themes were addressed: Develop Intelligence, Perform Predictive Analysis, Share Situational Understanding, Sustain Unit Operations, and Employ FCS Capabilities. This vignette utilized the instructional aid of the 3D avatar, LT Michaels, platoon leader of 2nd Platoon, Charlie Company. It demonstrates how he supports the Company attack of the objective by establishing blocking positions to block enemy forces attempting to flee the objective. The four learning points include:

- Understand how FCS units developed intelligence at the lower levels.
- Understand how FCS units performed predictive analysis at lower echelons.
- Understand how Sharing Situational Understanding allowed for interoperability of FCS-networked units.
- Observe a demonstration of How to Sustain Unit Capabilities within the FBCT.

6.0 DISCUSSION AND CONCLUSIONS

This research and training development effort contributed to the collective understanding of requirements for preparing Soldiers and leaders for Future Force capabilities. We identified a set of FCS cognitive requirements and generated exemplar embedded training vignettes to more rapidly prepare operational units for the challenges of the FCS operating environment.

Given the limited depth of this research and the small sample size obtained during the content validation phase, the identification of the eight cognitive themes lacks statistical rigor. There remains some doubt that the constructs comprising these themes could be replicated across time in similar situations.

Furthermore, it is important to note that the FCS environment remains an envisioned world as opposed to a fully developed, tested, and implemented operational environment. The design of the command and control technologies and the concepts and processes for operating within the environment continue to evolve and change as new Soldier and unit demands are revealed. Therefore, it is conceivable that the cognitive requirements we have described would also continue to evolve over time as FCS development and CAB training continues. It is possible that if we repeated the CTA effort at a later date, the cognitive requirements would closely resemble, but not identically replicate, those described by our eight themes. Despite the potential for FCS cognitive requirements to mutate over time, we have confidence that the CTA and Content Validation efforts have produced a set of pilot themes to guide the development of robust cognitive skills training for FCS Soldiers.

Just as the FCS concepts and technologies evolve with exercise and experimentation, so must the analysis of cognitive requirements for Soldiers and leaders and the cognitive skills training that is produced as a result. We recommend a follow-on study with the intent of using the eight cognitive themes described in this initial research as a starting point in conducting a confirmative factor analysis using structural equation modeling.

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